

MASSACHUSETTS
INSTITUTE OF TECHNOLOGY,

BOSTON, MASS.

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DEPARTMENT OF BIOLOGY.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

BIOLOGY.

For those who desire a technical education in the physical and natural sciences the Institute has made provision in the courses in Chemistry, Physics, Geology, and Biology.

THE DEPARTMENT OF BIOLOGY deals in general with all organisms. It deals most extensively with the lower organisms, such as ferments, molds, algæ, fungi, animalcules, and bacteria; less extensively with the higher organisms, under the head of Physiology and Morphology, and, to some extent, under Zoölogy and Botany; very briefly with man and his place in Nature, under Anthropology. These subjects, dealing with concrete natural phenomena, and involving constant practice in observation and experiment, generalization and verification, have great educational value.

The microscope is the principal instrument employed by biologists, and biology is, therefore, sometimes regarded as merely microscopical science. But it is much more than this. It involves not only the patient and minute investigation of the structure and behavior of organisms, but also the logical interpretation of these phenomena and the scientific application of them to human affairs. It is now well recognized that biology, in its modern aspects, touches at many points the intellectual life of the times; but it is not generally recognized that it touches, also, at quite as many points the practical everyday life of the people. At the present time this contact is perhaps most conspicuous in the connection of biology with the theory and the practice of sanitation, a subject of the deepest interest to individuals and communities alike. But it is by no means here alone that biology becomes a practical subject. In industrial science, also, and in the arts, processes absolutely dependent upon the life of ferments are now very extensively carried on, while immense industries are obliged to cope with putrefaction and decay. For the preservation of food or timber, costly processes of various kinds must be employed — as, for example,

canning, refrigeration, or antisepsis—all of which depend upon the successful control of the vital activity of low organisms, and many of which involve important economic and sanitary questions. The great problems of public sanitation, such as the purity of public supplies of water, of milk, and of ice; and questions of drainage, water filtration, and sewage purification or disposal have recently begun to feel the quickening influence of biology. It is already well recognized that for the solution of problems such as these the services of expert biologists are as indispensable as are those of chemists or engineers.

The principal endeavor of those in charge of the biological department is to lay, at the outset, a broad and firm foundation in the fundamental principles of biology with the assurance that however great may be the changes in their application, these shall remain established. Accordingly, the student begins his biological work with a course in **GENERAL BIOLOGY**, with particular reference to its fundamental relations to other subjects. This course is conducted by the head of the department, who thus comes in direct personal contact, at an early period, with all students in the course. The divisions of this class are kept small so that there shall always be opportunity for cross-examination, for conference and debate, as a means of information and of logical discipline.

Here, also, the elementary anatomy and physiology of organisms in general are studied from representative examples of plants and animals. Such subjects as organs, tissues, cells, protoplasm, differentiation, vital energy, work, adaptation, environment, primitive metabolism, and the fundamental physiological properties of all living things, are dwelt upon and made real by laboratory exercises upon illustrative forms. The use of the microscope and the pencil, the forceps and the scalpel, in this course gives practice in elementary technique, and prepares the way for subjects of greater difficulty which are soon to follow. The elements of **ZoöLOGY** and **BOTANY** are taught likewise with constant laboratory practice, each having its peculiar methods. These are followed by more advanced work in **COMPARATIVE ANATOMY** and **EMBRYOLOGY**, and these again by **PHYSIOLOGY**, in which the fundamental principles of the actions and functions of all organisms are dwelt upon at length. Finally, the principles thus established and illustrated are brought to bear upon the micro-organisms, which are studied partly in a laboratory course in **BACTERIOLOGY**, and partly and still more practically under the head of **SANITARY BIOLOGY**.

Bacteriology, with special reference to sanitary works, is a prominent feature of the final year. The students learn how to make their own culture media, how to examine milk, water, air, ice, soils, etc., and how to test the efficiency of filters, sterilizers, and germicides. Here, as in all the other courses mentioned, constant laboratory work is required. In HIGHER BIOLOGY lectures are given upon Darwinism, heredity, natural selection, degeneration, variation, phagocytosis, immunity, etc.

Especially noteworthy are the courses bearing directly upon sanitary science. In one of these the biological phenomena of communities, such as population, birth-rate, death-rate, morbidity, and lethality, are reviewed. Ancient and modern theories of disease are compared, while the causes of death, longevity, and other social phenomena ; the origin and natural history of epidemics ; the pollution and the purification of water ; the disposal of sewage, garbage, and the dead ; the phenomena of dust and its dangers ; the pollution of milk, food stuffs, and ice ; the self-purification of rivers, and the like, are carefully considered.

It is believed that those who graduate from this department are thus not only well grounded in the principles of biology, but are also familiarized with its technical applications. They may therefore enter at once upon their professional work as assistants in biological laboratories, or to Boards of Health, Water Boards, or Sewer Departments of cities ; to Superintendents of Water Works, or Manufacturers of certain chemical products ; or in the supervision of refrigerating establishments ; food-preserving or canning industries ; public milk-supplies ; ice-supplies ; or other technical affairs. Those who prefer to teach biology will find themselves fitted to enter their profession and ready to specialize. Those who look forward to the medical profession after their graduation may begin their medical studies with the assurance that their acquaintance with organisms in the normal state will be of the highest advantage to them in their studies of disease.

The Course in Biology includes many subjects besides those referred to above. It is the established policy of the Institute to make every one of its twelve courses which lead to the bachelor's degree, as broad and as liberal in educational effect as is consistent with the best professional training. In the first year of the school these courses are much the same for all, the endeavor being to establish the necessary foundation and to secure certain indispensable attainments.

The differentiation of the courses begins with the second half of the first year. During this term those who have decided to follow the course in Biology take somewhat less of Mechanical Drawing than the rest of the class, and devote the time thus gained to microscopical work in the biological laboratory. They also substitute for Spherical Trigonometry during this term a short course in the elements of Analytic Geometry. In the second year the differentiation of the courses goes much further, and subjects of technical importance begin to appear in all. In biology the separation from the engineering courses is now wide, but the connection with the chemical, physical, and geological courses is still comparatively close. In the third year this connection becomes less conspicuous but is still considerable; while all the courses of the school retain a common bond during the whole of the first three years in their studies of language, literature, economics, and physics. In the fourth and final year, however, the separation becomes complete. The professional work in each course now requires most of the student's time. The biologist is no longer required to continue chemistry, or history, or languages, although if he wishes he may do so to some extent. In his fourth year he is expected to devote himself almost exclusively to professional work, and a considerable portion of the second half of this year must be spent in the preparation of an original memoir or thesis upon some subject in biology, embodying observations, experiments, and conclusions not previously made. (See p. 9.)

From this brief sketch of the general plan of the Institute courses it will readily be seen that every course is intended to be as broad and liberal as it can be and still achieve its due result in professional attainment. The course in biology is no exception. The student, before he graduates from the biological department, must have had three years of continuous study of literary subjects, including a course in English Literature; one and one half years of history and political science; three years of chemistry, with constant laboratory work; two years of physics, including three fourths of a year in the physical laboratory; two years of freehand drawing; and one and one half years of geology, including mineralogy and blowpipe analysis. It is obvious that any one who has faithfully pursued all of these subjects, and has, besides, attained to such proficiency in his chosen specialty, biology, as to have completed at least one piece of original work, has obtained, not merely a technical, but also a liberal education. The titles of the subjects included in the course, and their sequence, are shown upon the opposite page:—

SCHEDULE OF THE COURSE IN BIOLOGY.

FIRST YEAR.

FIRST TERM.	SECOND TERM.
Solid Geometry. Algebra. General Chemistry. Chemical Laboratory. Rhetoric and English Composition. French (or German). Mechanical Drawing. Freehand Drawing. Military Drill.	Plane Trigonometry; Elements of Analytic Geometry. General Chemistry; Qualitative Analysis. Chemical Laboratory. Political History since 1815. French (or German). Mechanical Drawing. Freehand Drawing. Microscopy. Military Drill.

SECOND YEAR.

FIRST TERM.	SECOND TERM.
General Biology. Analytical Chemistry (Qualitative). Physics. Theoretical Chemistry. English Literature. American History. German. Zoölogy.	Elementary Botany. English Literature and Composition. Physical Geography. German. Physics. Zoölogy. Analytical Chemistry. Mineralogy and Blowpipe Analysis.

THIRD YEAR.

FIRST TERM.	SECOND TERM.
Comparative Anatomy. Biology of Micro-organisms. Structural and Chemical Geology. Physics; Heat. Physical Laboratory. Political Economy. Business Law. German. Anthropology (lectures). Analytical Chemistry (lectures and laboratory). Freehand Drawing.	Comparative Anatomy and Embryology. Cryptogamic Botany. Historical Geology. Physical Laboratory. Business Law. Political Economy and Industrial History. German. Sanitary Chemistry. Freehand Drawing.

FOURTH YEAR.

FIRST TERM.	SECOND TERM.
Comparative Physiology. Microscopic Anatomy. History of Natural Science. Theoretical Biology. Bacteriology. Journal Club. <i>Options.</i> 1. { History and Literature of the Renaissance and the Reformation. Climatology. 2. { Organic Chemistry. Organic Analysis.	Comparative Physiology. Microscopic Anatomy. Sanitary Science and the Public Health. Theoretical Biology. Journals. Thesis Work. <i>Options.</i> 1. { History and Literature of the Renaissance and the Reformation. Sanitary Biology or Social Science and History. 2. { Organic Chemistry. Sanitary Biology.

The Biological Laboratory is located upon the ground floor of the Rogers Building and is well suited for microscopic work. It is provided with microscopes of different kinds for the use of the different classes; with microtomes for the cutting of thin and serial sections; with paraffine baths for imbedding; with thermostats for constant temperatures and use in bacteriological work as well as for artificial digestions; with culture rooms, sterilizers, culture dishes, and standard cultures of bacteria; with aquaria, and a stock of representative thallophytes for cryptogamic botany; with models, and an excellent set of lecture charts and diagrams in the several subjects of instruction; with instruments for experimental physiology, such as a rotating drum for smoked paper, a long-roll kymograph, a pendulum myograph, Du Bois-Reymond induction machines, moist chambers, etc. Nearly everything used by the student is supplied or loaned to him free of charge, and there are no special or extra fees in this department.

Library and Museum Facilities. A good working library, including many special monographs, is placed in the laboratory itself and is thus in constant use. The laboratory is on the same floor with the general library of the Institute, and in the same building with the valuable library of the American Statistical Association, which is rich in the department of vital statistics. It is also midway between the excellent sanitary library bequeathed to the Institute by the late Professor William Ripley Nichols, which is now deposited in the chemical department, and the large library of the Boston Society of Natural History, to both of which students of biology have full access. Besides these nearer libraries, the Boston Public Library, the Boston Medical Library, the two libraries in the Athenæum building, and others, are accessible under certain restrictions.

The situation of the biological laboratory in the immediate vicinity of the Museum of the Boston Society of National History affords special advantages, the collections and the meetings of the Society being always open to students of biology in the Institute.

Special Facilities. The incidental advantages and opportunities of the biological department, in connection with the Institute of Technology, are very great. The department of chemistry is provided with an excellent sanitary laboratory; and in the work which is there being done upon the natural waters of Massachusetts for the State Board of Health, there are very unusual opportunities for investigation and instruction. Similar work, from the biological point of view, is being

done (also for the State Board of Health of Massachusetts) in the biological laboratory itself, thus giving equally valuable opportunities for investigation and instruction in sanitary biology. The department of sanitary engineering also supplements the biological instruction in sanitary science, and in the department of physics the special worker in biology may receive instruction in heating and ventilation.

For the information of special students not candidates for a degree it may be said that the biological laboratory is much resorted to by teachers and others of mature age, who desire to perfect themselves in one or more subjects. Excellent opportunities are now available in this department for superintendents of water works, sanitary inspectors, and others who may desire to fit themselves more fully for their professional work. In the various aspects of the science of sanitation the Institute offers peculiar advantages; and in all subjects relating to micro-organisms the biological department is prepared to give special instruction.

The need for trained biologists is now very great, and it is at present difficult to secure graduates enough to fill the places as fast as they appear.

TITLES OF THESES.

The following are the subjects of some of the graduating Theses in Biology during the last five years :—

A Biological Study of the Charles River at Charles River Village, and at Newton Upper Falls, and of the Water Supply of Newton, Mass.

A Biological Study of the Water Supply of Waltham, Mass., and of the Charles River at Waltham and Watertown.

Thermal Stimuli as a source of Reflex Action.

An Investigation of the Effect of Electricity on Micro-organisms.

The Microscopical Analysis of Potable Waters by a new Quantitative Method.

A Sanitary Bacteriological Study of the Milk Supply of Boston.

A Study of the Zoöglœa Stage of Bacteria.

The Action of Different Bacteria in the Decomposition of Casein and Milk Sugar.

Amœba Proteus; An Investigation of its Life-history and Physiology.
A Description of Some of the Species of Bacteria found in the
Cochituate Water Supply.

The Life-history and Physiology of the Thread-leaved Sundew.
(*Drosera filiformis, Raf.*)

The Physiology of Digestion in the Starfish.

The Decomposition of Milk by Bacteria.

The Physiology of the Circulatory and Nervous Systems of the
Earth-worm.

The Occurrence of the Eberth-Gaffky Bacillus in Excreta.

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 CHARLES L. ADAMS, Instructor in Freehand Drawing.

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